Atomic Force Microscopy Study of Surface Morphology of Nanomaterials

Yeboah, Clark Atlanta

Surfaces and interfaces are important in explaining nanomaterial behavior. Developing an understanding of the characteristics of the interphase region, its dependence on nanoelement surface chemistry, the relative arrangement of constituents and, ultimately, its relationship to the properties, is a focus of the research at CAU. Equally important is the development of a general understanding of the morphology-property relationships for mechanical, barrier, and thermal response of these systems. This necessitates the determination of the critical length and temporal scale with which continuum description of a physical process must give way to mesoscopic and atomistic view of these nanoscale systems—a current challenge for computational materials science. An AutoProbe CP Research Scanning Probe Microscope available at the Research Center for Science and Technology at Clark Atlanta University, is used to study materials 3-D surface topographies and surface property measurements in air and liquid. The AutoProbe CP Research is equipped with standard and advanced imaging capabilities including scanning tunneling microscopy, contact, non-contact, intermittent contact AFM, lateral force microscopy , phase detection microscopy (phase imaging), point spectroscopy, layered imaging AFM, pulsed force mode, force modulation microscopy, scanning thermal microscopy, scanning capacitance microscopy, magnetic force microscopy, and electrostatic force microscopy. Experimental data obtained regarding interfaces and interphases will be used to validate numerical models to fully understand and predict interface/interphase development from fundamental thermodynamic and kinetic principles. Significant effort is focused on the ability to obtain control of the nanoscale structures via innovative synthetic approaches.

Atomic resolution images of a variety of nanophase materials including mesoporous organosilicates, electroplated Ni/Fe, and nano-embedded cerium particles in an alumina matrix, and copolymers (poly(2-methoxystyrene)-co-poly(ethylene oxide) have been obtained. Mesoporous materials are porous materials with regularly arranged, uniform mesopores and are used as adsorbents or catalysts. Recently, new functional composite materials have been prepared by incorporating various guest species into the pores of mesoporous materials. Several applications, such as micro-lasers, solid electrolytes and fluorescent films, have been reported. AFM is used as an analytical tool to aid in the study of the synthesis and testing of inorganic mesoporous catalysts to address the growing demands for improved catalysts for the upgrading of heavy feed stocks such as heavy crudes and petroleum. Figure 1 shows a 50 nm scan. Pore size on the order of 1.6 nm was measured.

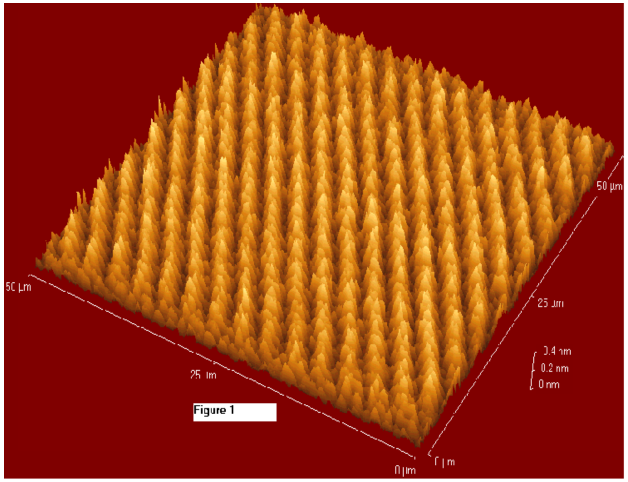

Figure 1

Figure 2 shows a 4 µm scan of an electroplated Ni/Fe material The surface morphology revealed pairs of islands of clusters. The surface roughness was found to be 0.34 nm. The global grain analysis showed a global volume of 0.005 μm^3 and a maximum height of 5.95 nm. The lateral spacing between the edges of the particles was 1.61 nm.

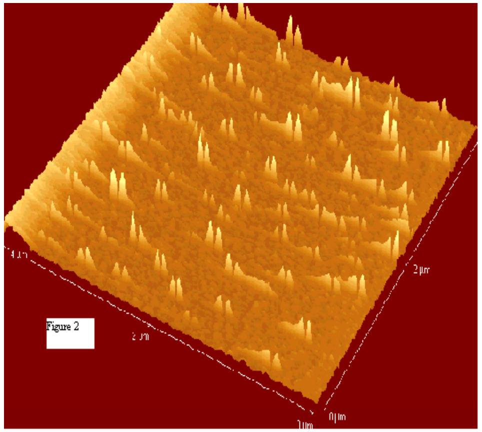

Figure 2